Rentex 1.2

Program operating manual

Issue No. : 1.0
Date of Issue : 07 - 2009

Z.U.T. NDT SOFT
http://www.ndtsoft.eu

Contents

1. Introduction ……...3

2. Basic operations…… 3

2.1. Program interface…….…….. 3

2.2. Initial setup……..4

2.3. Calculation of exposure time..……..……....….7

2.4. Printout of radiographic techniques…….....……..9

3. Advanced features……..... ……11

3.1. Exposure auto-correction system.....11

3.2. Correction data from test radiographs…….....12

3.3. Using of exposure correction system…….....…..14

3.4. Testing materials other than steel…….....……..15

1. Introduction

Rentex 1.2 software program is an advanced industrial radiography calculator supporting conventional radiographic testing carried out with X-ray tubes and standard radiographic films.

Rentex 1.2 will operate on the following Windows platforms: Windows 98 SE, Windows Me, Windows 2000, Windows XP and Windows Vista.

The program has the following features:

- Calculation of exposure times for radiographic examinations carried out with different models of X-ray tubes in dependence of tube setup parameters (voltage, current), film type/class, material thickness, focus film distance and required optical density of radiographs
- Integrated exposure correction system enabling adjustment of program exposure calculation algorithm to the specific working/processing conditions in the user laboratory
- Preparation and printout of radiographic techniques with all parameters of the planned exposures
- Database of X-ray tubes where user can introduce exposure parameters of its X-ray tubes. The introduced data are subsequently used by the program in exposure calculations
- Database of tested materials with their radiographic equivalence factors. The factors are used for calculation of exposure times when testing materials other than steel

The following manual is composed of two parts. In the first one, titled ***Basic operations***, only basic program functions are explained. It is intended to give the users the first impression of program design and usability without going into too much details.

In the second part titled, ***Advanced features*** the reader can learn more advanced program features making it an exceptional tool supporting everyday work in radiographic laboratory.

2. Basic operations

2.1 Program interface

After installation and registration of the program on your computer you can start it by double clicking on the shortcut icon placed on the Windows desktop.

Fig. 1. Rentex 1.2 shortcut icon on the Windows desktop.

When the program is started its main window is displayed from where you can reach all its basic functions, options, setups and help files.

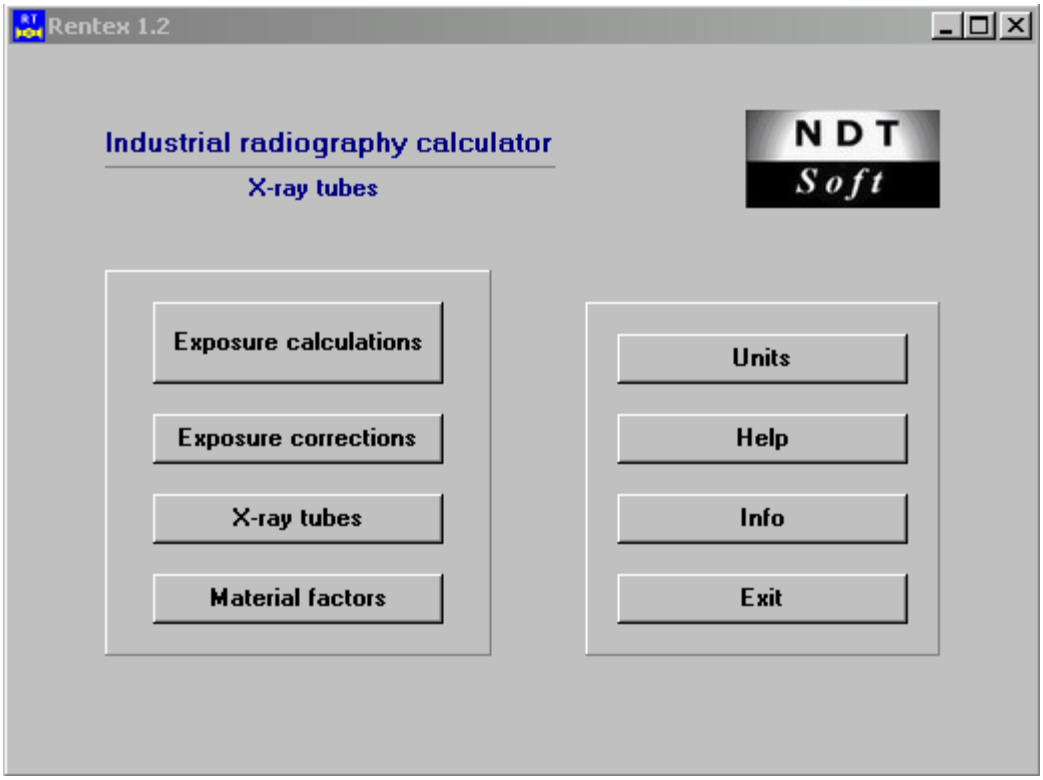

Fig. 2. Main window of the Rentex program.

When you start the program for the first time you have to make its initial setup which, as a minimum, requires choosing of measurement units (Metric or Imperial) and specifying exposure parameters of X-ray tubes used in your laboratory.

2.2. Initial setup

To choose the measurement units click on the ***Units*** button in the main window and open the following box:

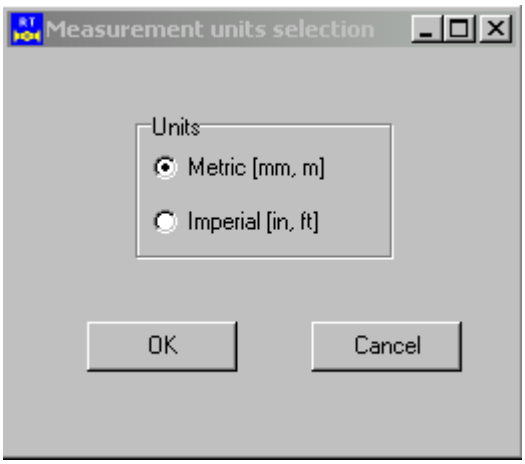

Fig. 3. Program box for selection of measurement units.

Click on the option you prefer and confirm your choose with ***OK*** button. All subsequent program calculation results and parameters will be expressed in units of your choice.

To specify parameters of your X-ray tubes click on the ***X-ray tubes*** button and open the following form:

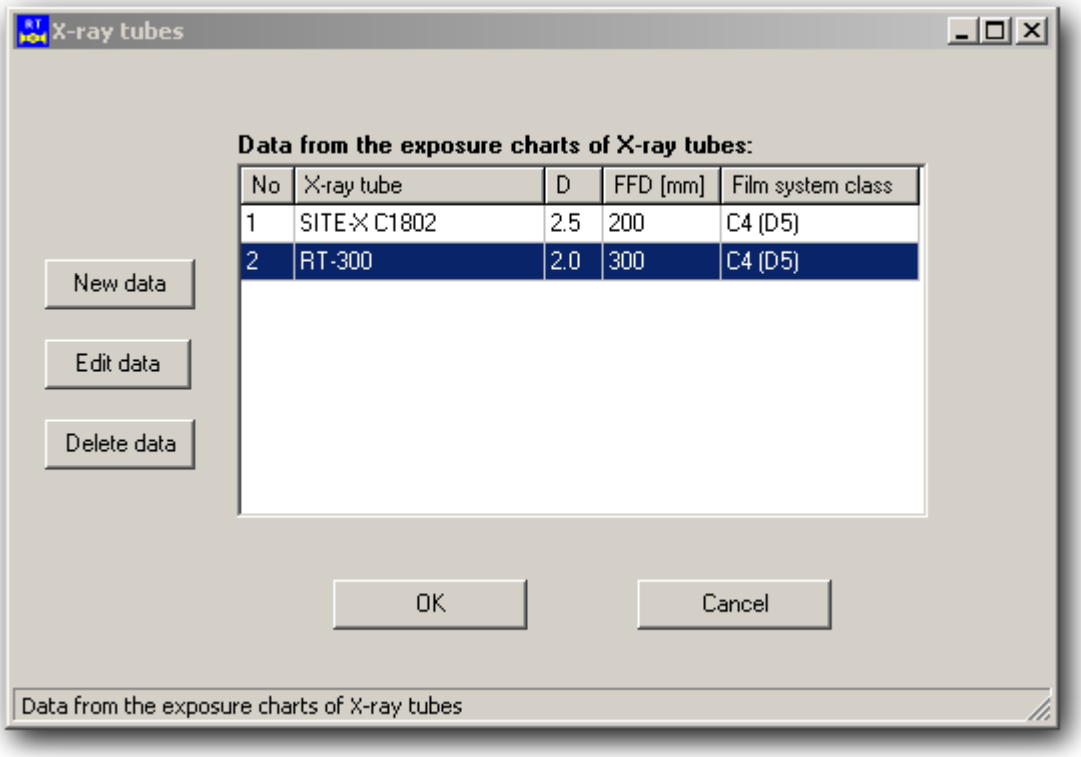

Fig. 4. Form displaying X-ray tubes data in the program database.

In the form you may find some example entries of X-ray tubes which can serve you as templates for introducing your actual data.

To introduce exposure parameters of a new X-ray tube to the program database click on the ***New data*** button and open the form shown in fig. 5. In the form enter the following parameters taken from the exposure chart of your X-ray tube:

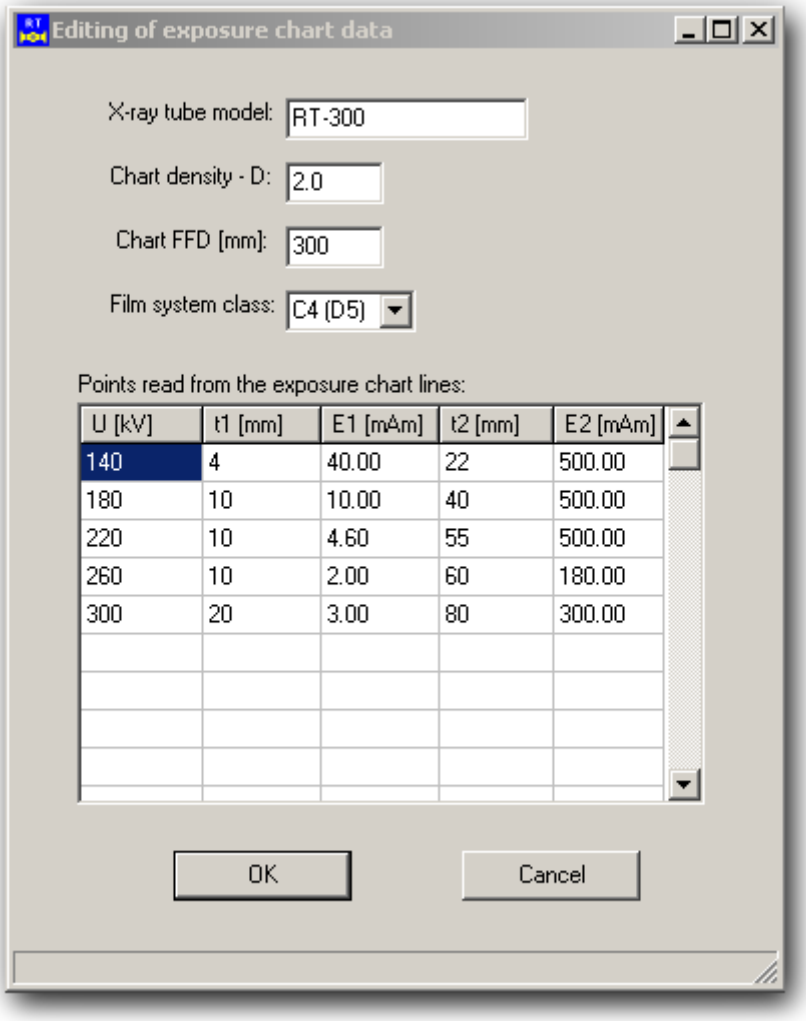

Fig. 5. Form for entering exposure parameters of an X-ray tube.

In *X-ray tube model* field enter the model name or another designation of your X-ray tube. In a given example it is RT-300. This entry will serve as the tube identification in all subsequent program operations.

In C*hart density – D* field enter the radiograph density indicated on the tube exposure chart for which this chart was prepared. In our example it is D = 2.0

In C*hart FFD* field enter the FFD (Focus Film Distance) indicated on the tube exposure chart for which this chart was prepared. In our example it is 300 mm.

In *Film system class* combo box select the film system class for which the exposure chart was prepared. This information may not be given directly on the exposure chart but may be easily inferred from film brand/type indicated on the exposure chart.

After filling in all these general information you have to enter detailed data concerning the individual lines indicated on the exposure chart. To this end you have to determine the coordinates of two points on each line. The whole thing is best explained on the example exposure chart displayed below.

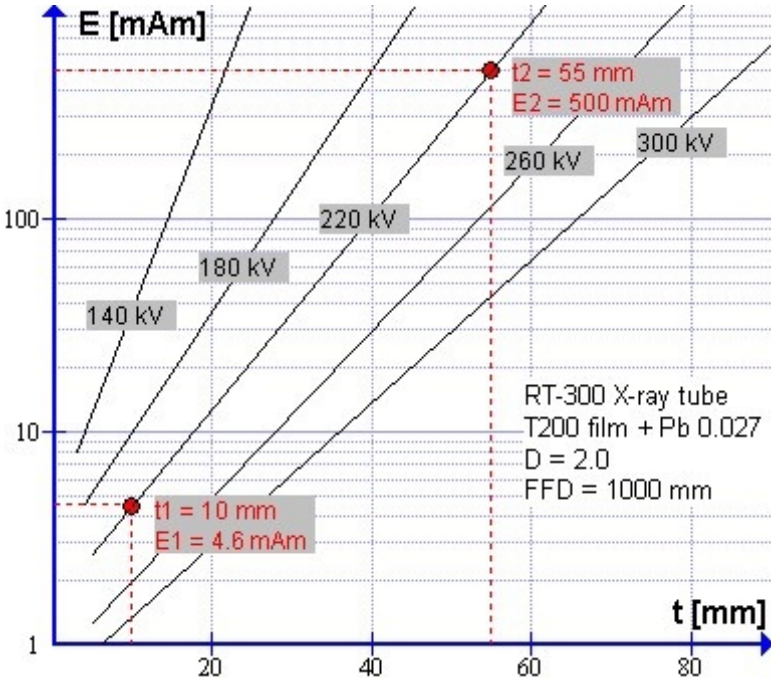

Fig. 6. Example exposure chart of X-ray tube with parameters which have to be transferred to the program database.

For every chart line you should determine its voltage and coordinates (thickness and exposure values) of two points. The example points lying on the 220 kV line are marked with red circles. Their coordinates are: (t1=10 mm, E1=4.6 mAm) for the first point, and (t2=55 mm, E2=500 mAm) for the second point. You should determine similar data for every line indicated on the exposure chart and enter them to the program table shown in Fig. 5. The total number of rows filled in the table should be equal to the number of lines on the exposure chart.

After filling in all required data click on the ***OK*** button and find your new X-ray tube in the table displayed in form shown in Fig. 4. To save the updated table in the program database click on the ***OK*** button**,** to discard changes click on ***Cancel***.

After entering to the program database parameters of your X-ray tubes you can start basic calculations of exposure values (mAm) for your radiographic examinations. Some more advanced program features will still require additional setup information based on executed test radiographs and other data. This subjects will be covered in ***Advanced*** section of this manual.

2.3. Calculation of exposure times

Calculations of exposure values for the planned radiographic examinations is the basic function of the Rentex program. To perform this task click on the ***Exposure calculations*** button in the main window and define parameters of your radiographic technique in the program form shown below (Fig. 7).

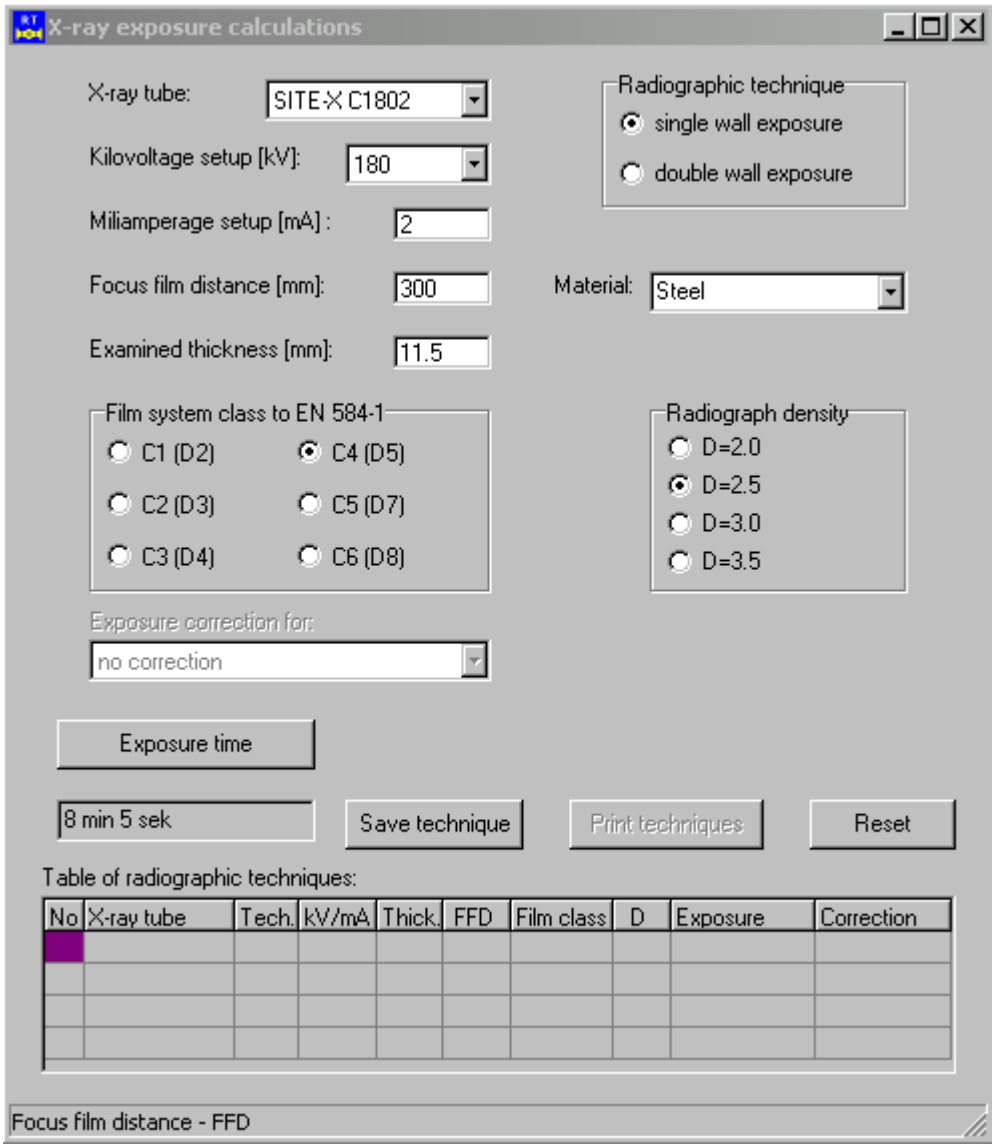

Fig. 7. Form for definition of radiographic techniques and calculation of exposure times.

In the exposure calculations form you should enter all parameters of the radiographic technique you plan to execute with use of an X-ray tube.

- In combo box '*X-ray tube'* choose the tube model which will be used for the planned examination
- In radio group *'Radiographic technique'* choose the type of radiographic technique for the planned examination. This selection is very important and considerably affects the calculated exposure values not only because of doubled penetrated thickness but also due to different accounting for scattered radiation.
- In combo box 'K*ilovoltage setup'* select the tube voltage value which will be set up for the planned exposures
- In edit box *'Miliamperage setup'* enter the tube current value which will be set up for the planned exposures

- In edit box 'Focus *film distance'* enter the distance between the focus of X-ray tube and radiographic film
- In edit box *'Examined thickness'* enter the examined material thickness (not the total penetrated thickness). It means that for double wall techniques you should also enter single wall thickness.
- In combo box '*Material' select* the type of material which you are going to test. Initially you can select only one of the 4 predefined materials (steel, aluminum, nickel, cooper). In *Advanced* section of this manual you learn how to add additional materials to this list.
- In radio group *'Film system class acc. EN 584-1'* choose the film system class which will be used for the planned examination. To ease your choose for each film class the symbol of commonly known film type of popular brand was added in parentheses. This, in any case, not restrict the use of program with other types/brands of films as long as you know their EN 584-1 classification.
- In radio group *'Radiograph density'* choose the optical density of radiographs you prefer
- In basic calculation mode the option: *'Use exposure correction for:'* is not active. Activation and using this option is explained in *Advanced* section of this manual.

After entering all above data click on the ***Exposure time*** button and program will calculate exposure time required for the specified set of examination parameters. Exposure time will be expressed in minutes and seconds.

Calculated exposure time, together with all other parameters of the elaborated radiographic technique, can be saved in the table of radiographic techniques by clicking on the ***Save technique*** button. The outlook of the table after saving of two example radiographic techniques is shown in the Fig. 8.

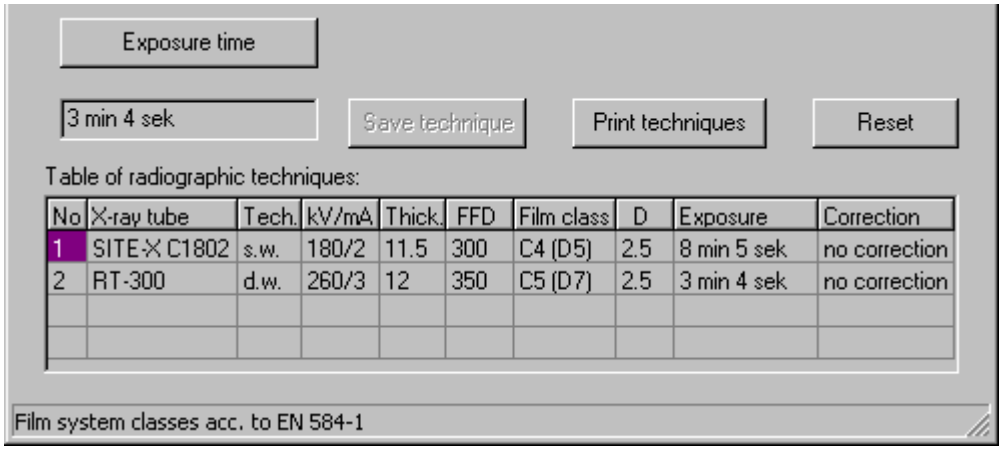

Fig. 8. Two radiographic techniques saved in the table.

You can save maximum 4 radiographic techniques in one calculation cycle. After saving 4-th technique you have to print them out by clicking on the ***Print techniques*** button or discard them by clicking on the ***Reset*** button. After that you can start preparation of the new set of techniques.

2.4. Printout of radiographic techniques

You can print out radiographic techniques saved in the techniques table by clicking on the ***Print techniques*** button.

The printout of radiographic techniques takes a form similar to shown in Fig. 9. For each technique all parameters necessary for its proper execution are specified. Such printouts can be handed to RT technicians as the job instruction sheets.

Rentex 1.2 2009-07-23

RADIOGRAPHIC TECHNIQUES

Technique No 1 - single wall exposure

X-ray tube model:	SITE-X C1802
X-ray tube setup:	180 kV / 2 mA
tested material:	steel
examined thickness:	10 mm
focus-film distance:	400 mm
film system class:	C5 (D7)
radiograph density:	D = 2,5
required exposure time:	**6 min 53 sek**
exposure correction for:	Film X+Pb0,027+Auto G135 30/8, k =1,05

Technique No 2 - double wall exposure

X-ray tube model:	SITE-X C1802
X-ray tube setup:	180 kV / 2 mA
tested material:	steel
examined thickness:	8 mm
focus-film distance:	400 mm
film system class:	C5 (D7)
radiograph density:	D = 2,5
required exposure time:	**33 min 34 sek**
exposure correction for:	no correction, k =1,00

Technique No 3 - single wall exposure

X-ray tube model:	RT-300
X-ray tube setup:	260 kV / 2 mA
tested material:	steel
examined thickness:	18 mm
focus-film distance:	450 mm
film system class:	C4 (D5)
radiograph density:	D = 2,5
required exposure time:	**4 min 37 sek**
exposure correction for:	no correction, k =1,00

Fig. 9. Printout of radiographic techniques worked out with Rentex program.

Calculations of exposure values described above do not make use of exposure correction system implemented in the Rentex program. It means that the effective 'film speeds' assumed for particular film system classes are certain averages elaborated by the program developer on the bases of data published by film manufacturers and feedback information received from the program users.

Calculations based on such averaged data may be sufficiently accurate for many users working in most typical conditions but, as with all other standard exposure calculation tools, for some combinations of testing/processing conditions they may lead to considerable errors.

To overcome this problem the Rentex program implements advanced exposure correction system enabling thorough adjustment of exposure calculation algorithm to the actual testing/processing conditions in the user laboratory. The system requires shooting test radiographs and entering their expected (planned) and resulted densities to the program database. The system design and way of its practical use is described in the ***Advanced*** section of this manual.

3. Advanced features

3.1. Exposure correction system

The common weakness of conventional exposure calculation tools (charts, sliding rulers, calculator programs etc.) is fact that they implement fixed computing algorithm which does not take into account all factors affecting the final radiograph density in real working conditions. The testing/processing conditions are not the same in every radiographic laboratory. They may differ in brand/types of used films, thickness of Pb screens, type and parameters of film processing, brand of chemicals used etc. All this factors matter and may cause difference between the planned and actually obtained radiographs densities even if all basic exposure parameters (FFD, material thickness, tube voltage) have been set up correctly.

To resolve this problem radiographers often determine so called *correction factors* which are used to correct the exposure time value calculated with the exposure calculator. Correction factors are established on the basis of executed test radiographs by comparison of their planned and actually obtained densities.

This approach works reasonably well when testing conditions in a given lab are much the same for all the jobs. When the laboratory uses multiple types of sources, brands/types of films and processing conditions it is necessary to determine several correction factors and use them in a consistent way. In practice it often leads to mistakes in exposure calculations and results in badly exposed radiographs.

To overcome this difficulty a unique exposure correction system was implemented in the Rentex program. It allows for adjusting the program exposure calculation algorithms to every combination of testing/processing conditions which may occur in industrial radiographic laboratory.

The basic principle of the implemented correction system is the same as in manual calculations of correction factors. For every practical combination of testing/processing conditions you make a test radiograph with exposure time calculated by the program in its standard mode (without correction). Then you measure the test radiograph density and introduce it to the program database together with the planned density and other parameters of the test exposure.

Having such feedback data gathered in its database the program can automatically calculate correction factors relevant to the particular set of testing/processing conditions and propose it to the user. The final decision on the use of a specific correction factor is always left to the user. He can choose one of the available correction options or apply the standard exposure calculation algorithm. Correction factors are calculated on the bases of film characteristic curves stored in the program memory.

3.2. Correction data from test radiographs

To explain how to use the exposure correction system we consider the example work scenario which may happen when using Rentex program.

Test radiograph of steel plate was shot with the RT-300 X-ray tube set to 260 kV on radiographic film of C5 class designated as FilmY. Lead screens (front and rear) of 0.1 mm thick were used to enhance the radiograph quality. Exposure time for density D=2.5 had been calculated using standard exposure calculation mode (no correction). The film was processed in automatic processor using G135 developer and 8 min/30°C processing cycle. After processing the radiograph density was measured and found to be lower then expected. Instead of being 2.5 it was only 2.13. Such difference was considered unacceptable and triggered action for adjusting the program exposure calculation algorithm to the actual testing/processing conditions. To calculate the relevant correction factor the program needed the feedback data from the executed test radiograph.

To enter these data to the program click on the ***Exposure corrections*** button in the main window and open the form *Exposure correction data* shown in Fig. 10. The form displays all correction data already introduced to the program.

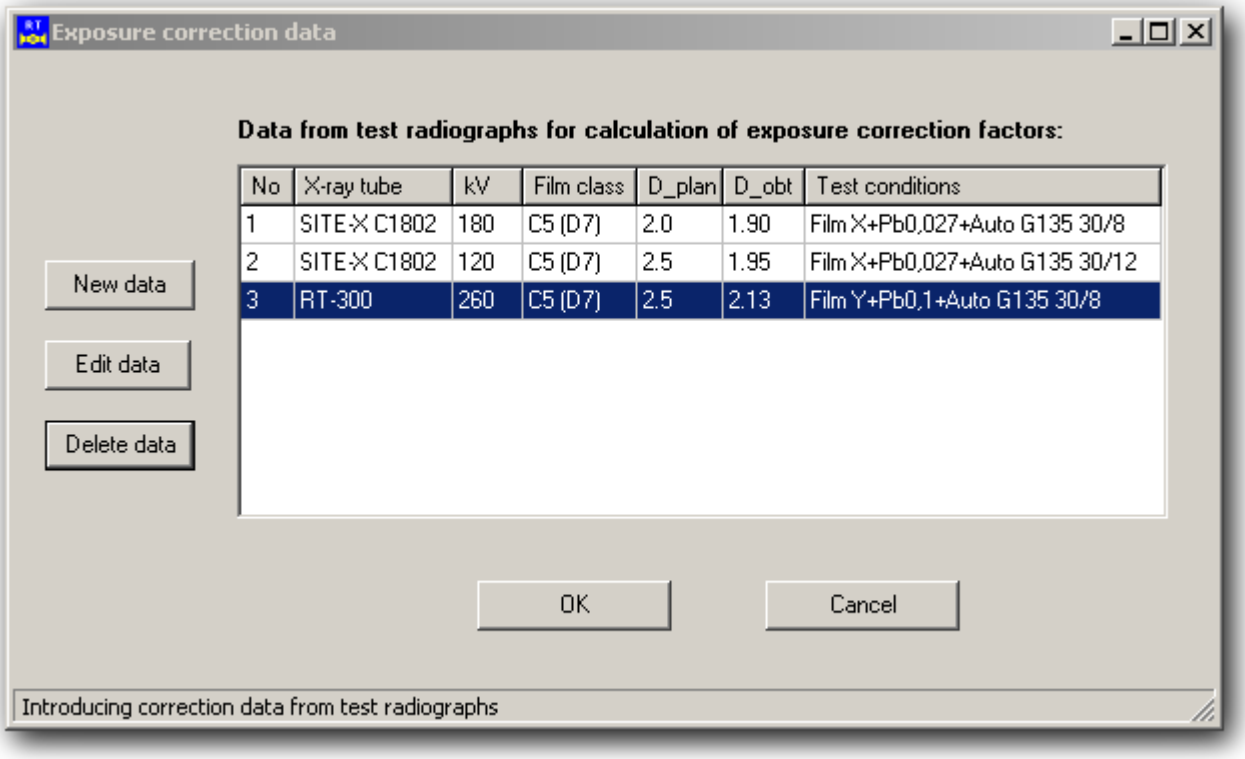

Fig. 10. Table of correction data taken from executed test radiographs.

To add a new data to this table taken click on the ***New data*** button and open the form shown below.

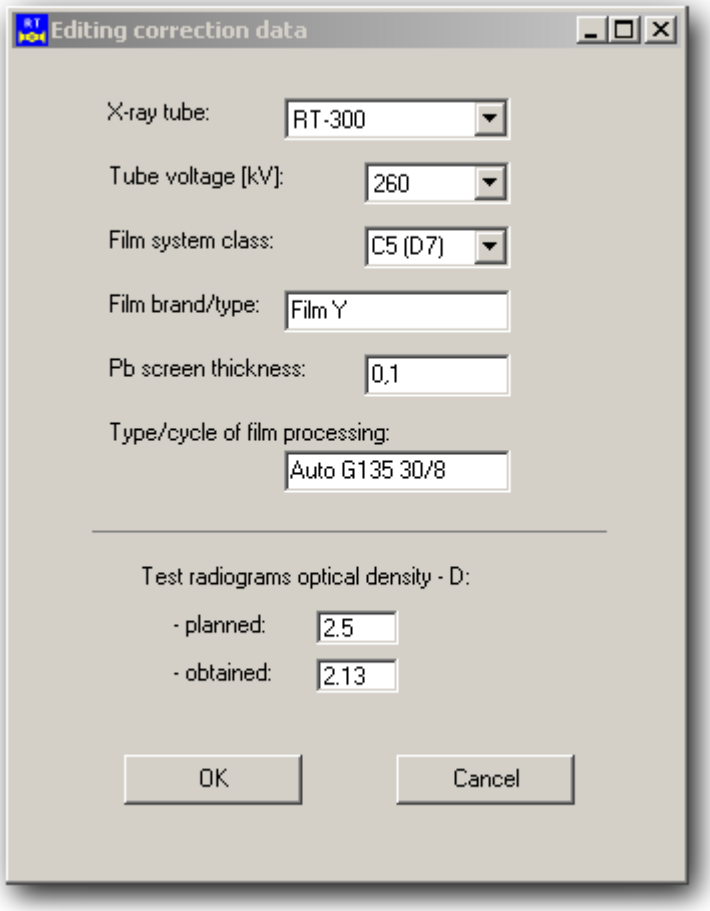

Fig. 11. Program form for entering correction data from test radiographs.

In the form enter the following data:

- In combo box *'X-ray tube'* select the type of X-ray tube which was used for making the test radiographs – in this case: RT-300
- In combo box *'Tube voltage [kV]'* select the kilovoltage which was set on tube for making the test radiograph – in this case: 260
- In combo box *'Film system class'* select the film system class which was used for making the test radiograh – in this case: C5 (D7)
- In edit box *'Film brand/type'* enter the specific brand/type of radiographic films used for making the test radiograph – in this case: Film Y
- In edit box *'Pb screen thickness'* enter the thickness of Pb screens used for making the test radiograph – in this case: 0.025
- In edit box *'Type of film processing'* shortly describe the type and parameters (time, temperature) of chemical processing used to develop the test radiograph – in this case: Auto G135 8/30
- In edit box *'The radiograph density - planned'* enter the optical density planned for the radiograph when calculating the exposure time in the standard mode – in this case: 2.5

- In edit box *'The radiograph density - obtained'* enter the optical density actually measured on the developed test radiograph – in this case: 2.13

To accept the entered data click on the ***OK*** button in this form and then on the ***OK*** button in the *Exposure correction data* form. From now on the program has the information necessary for calculation of exposure correction factor for the test conditions specified in our example.

In the same way you can enter correction data corresponding to every combination of testing/processing conditions used in your laboratory. The entered information is stored in the program database and can be used by the program in subsequent exposure calculations performed for similar testing/processing conditions.

3.3. Using the exposure correction system

To illustrate how to use exposure correction system we open the exposure calculation form and perform exposure calculation for the similar testing/processing conditions as in our former example. The exposure calculation form with relevant parameters is shown in the fig. 12.

For specified X-ray tube, its voltage and film system class the program found in its database two matching sets of correction data enabling calculation of correction factors.

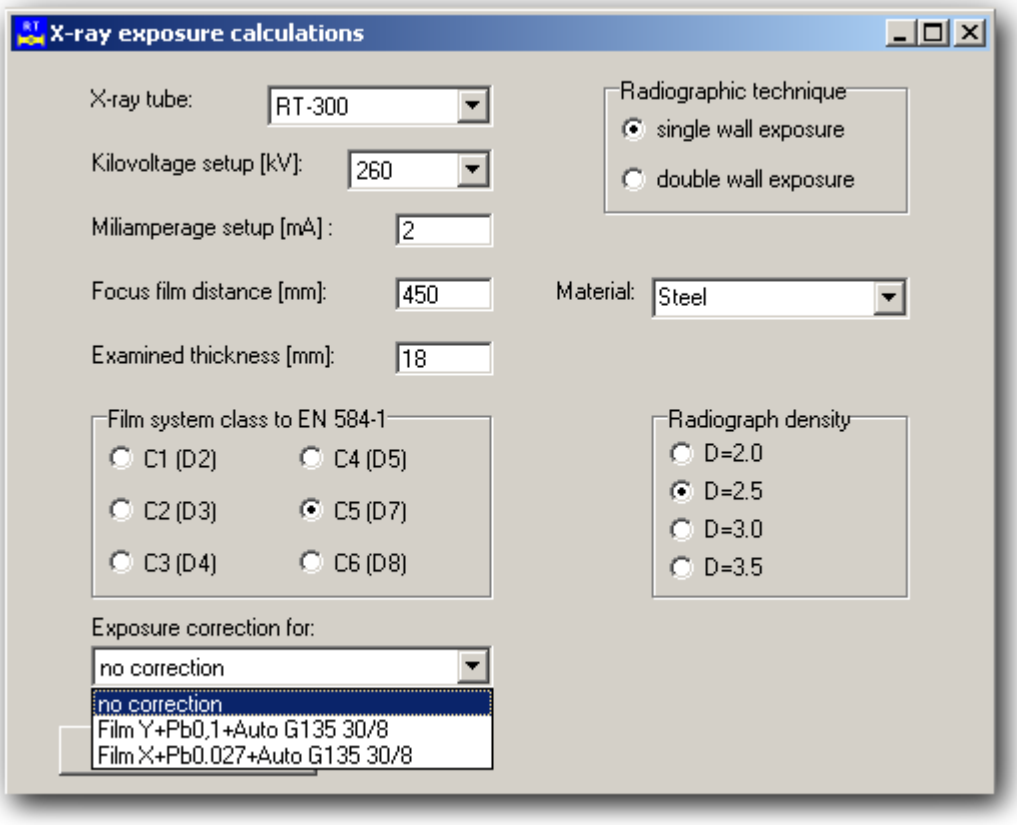

Fig. 12. Exposure calculation form with two correction options available.

They are displayed on the screen when user opens the combo box '*Exposure correction for:*' (see fig.12). Now we have to decide which correction option is most suitable for the planned examination. In our example it will be the second option because we are going to use FilmY

with Pb screens of 0.1 mm and develop it in automatic processor in 8 min/30°C cycle with G135 developer.

After choosing this option the program will automatically calculate the suitable correction factor and use it in the calculation of exposure value. The result of such a calculation is displayed in the Fig. 13. together with the exposure value calculated for the same testing conditions in standard mode (no correction).

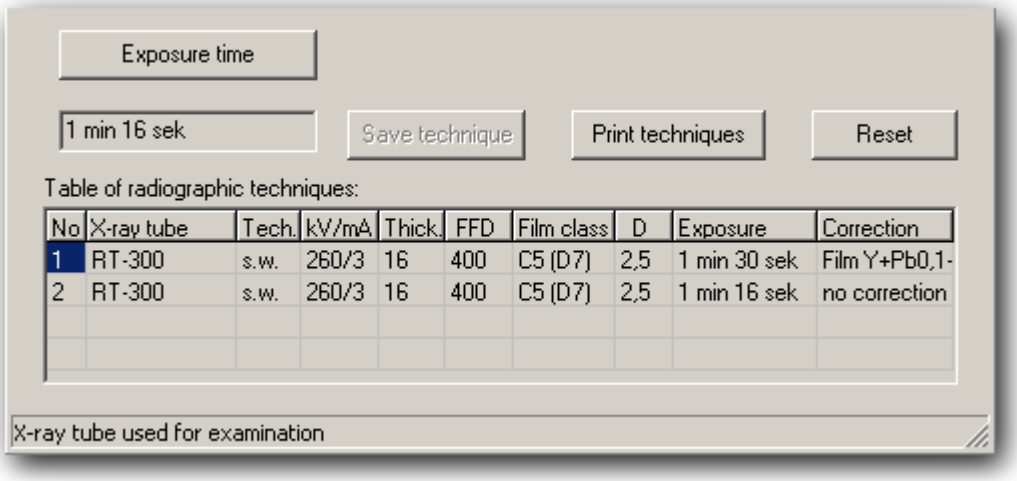

Fig. 13. Exposure times calculated with and without use of exposure correction factor.

As can be seen the corrected value (1 min 30 sek) is longer than standard value (1 min 16 sek) and should give radiograph density much closer to the required D=2.5 than value calculated without correction.

The option *'Use exposure correction for:'* will be active only for those combinations of testing conditions for which corresponding correction data have been introduced to the program database. It means that for a maximum accuracy of program calculations test radiographs should be executed for all typical combinations of testing/processing conditions used in a given laboratory. In case of substantial changes in testing conditions (e.q. introducing new type of films, changing processing conditions etc.) new test radiographs should be taken and updated correction data introduced to the program.

3.4. Testing materials other than steel

Exposure calculations are usually performed for steel which is most commonly tested material. When items made of other materials are to be tested the so called *radiographic equivalence factors* are used for conversion of actual material thickness to the equivalent thickness of steel.

The value of radiographic equivalence factors for a given material is not constant but depends on the radiation energy. This dependence is especially important for low energy X-ray sources as most of X-ray tubes. It means that radiographic equivalence factors should be defined for a given material and for a given kilovoltage value.

The approximate values of *radiographic equivalence factors* for some commonly tested materials at typical kilovoltage values are tabulated in handbooks on industrial radiography. On that bases equivalence factors for aluminum, titanium and cooper at 220 kV were predefined in

the Rentex program. They can be displayed on the screen by clicking on the ***Material factors*** button in the main window (see Fig.14).

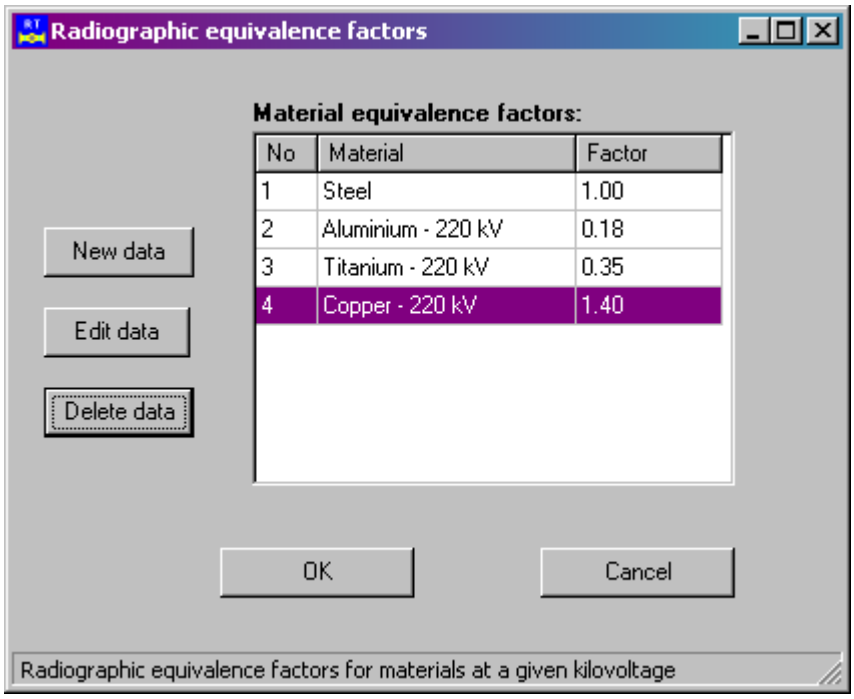

Fig. 14. Table of radiographic equivalence factors predefined in the program database.

For testing of other materials or at other radiation energies the users need to determine and enter radiographic equivalence factors on their own. The procedure of entering a new equivalence factor to the program database is described below. In the form *'Radiographic equivalence factors'* click on the ***New data*** button and open the box shown in Fig. 15. In this box fill in the following data:

- In edit box '*Material/kV'* enter the symbol of the material and kilovoltage value for which radiographic equivalence factor will be introduced
- In edit box *'Radiographic equivalence factor'* enter the value of radiographic equivalence factor for the specified material at specified kilovoltage

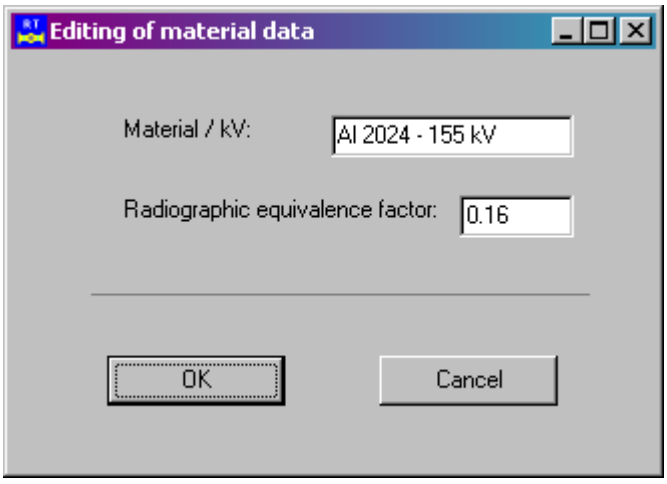

Fig. 15. Entering of radiographic equivalence factor for a new material/kilovoltage.

Click on the ***OK*** buttons two times to introduce the new material data to the program database. From now on you can calculate exposures for testing items made of this material at specified kilovoltage. You can just select it from the list of materials displayed in the exposure calculation form (Fig. 16).

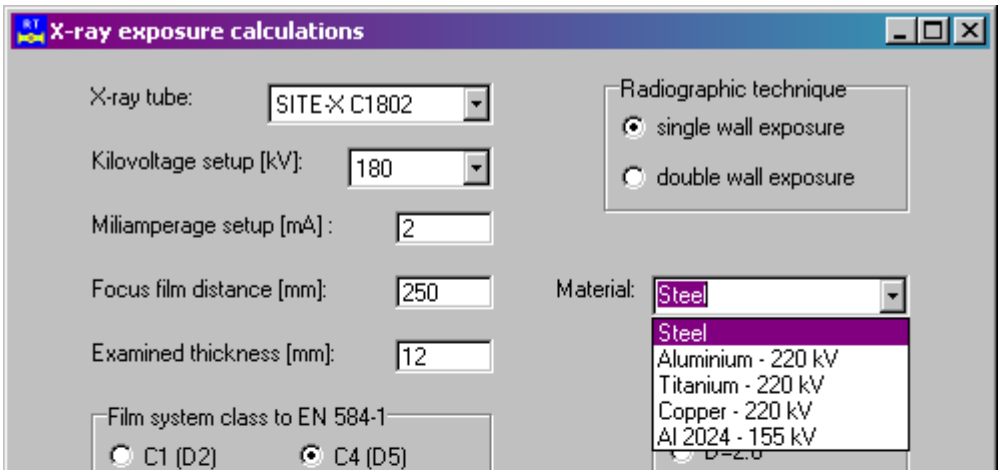

Fig. 16. Exposure calculations form with a new material option (Al 2024 – 155 kV) available.